# Complex Wide Waste Flow Analysis

Complex Wide Waste Flow Analysis (CWWFA) is a communication and policy analysis tool that can be used to evaluate strategies and provide information for environmental managers and stakeholders on complex waste management systems. The tool can be used to estimate cost savings, reduce health and safety risk and waste volumes, and minimize waste shipments and disposal quantities. CWWFA was developed by Lockheed Martin Idaho Technologies Company at the Idaho National Engineering and Environmental Laboratory (INEEL) using a systems engineering approach to defining and implementing needed functionality based on customer requirements.
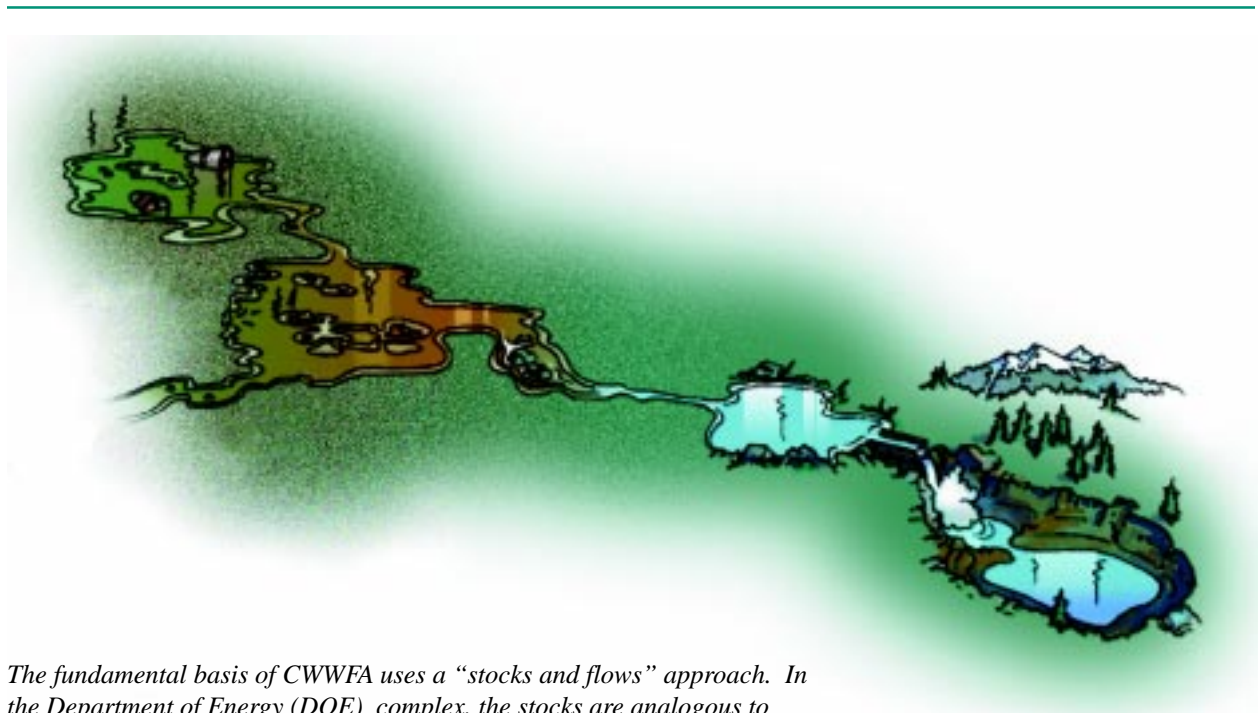
The fundamental basis of CWWFA uses a "stocks and flows" approach. In the Department of Energy (DOE) complex, the stocks are analogous to storage or disposal and flows occur during the treatment or transport of the waste. The simulation basis is also applicable to other systems such as a manufacturing and distribution network or river system of reservoirs and streams.

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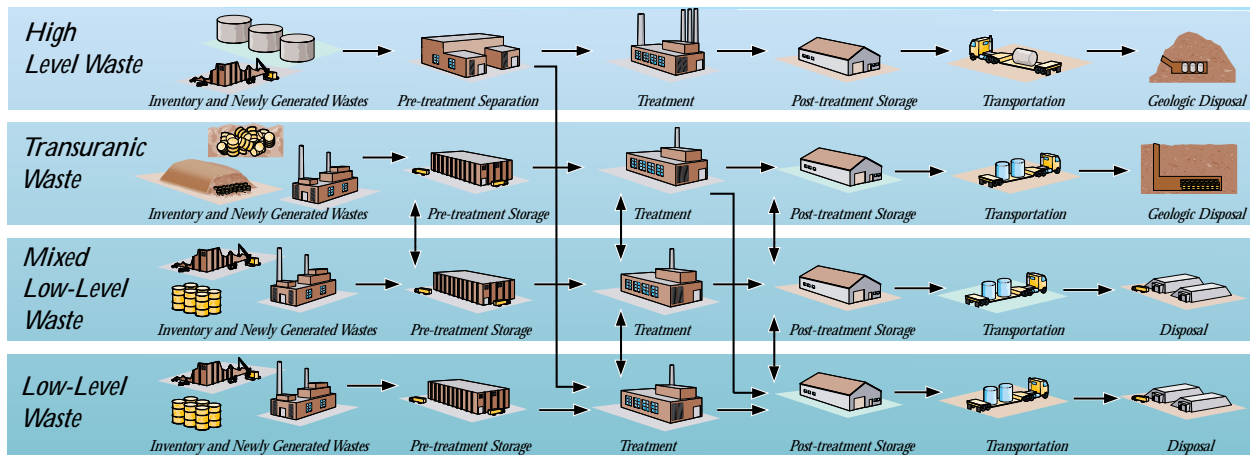
The model simulates waste flows between storage, treatment, and disposal facilities throughout the DOE complex for current inventories and newly generated waste from activities such as environmental restoration or decontamination and decommissioning.

Waste Flow Analysis Objectives

The purpose of CWWFA is to provide a high-level tool for systems analysts to evaluate a wide range of waste disposition alternatives. An alternative could represent different policy options by varying waste volumes, storage requirements, treatment systems, transportation relationships between sites, and disposal concepts. Based on these parameters, CWWFA simulates the movement of waste between management activities and sites.

Data Validation Tool

For a given alternative, CWWFA is very useful in highlighting waste flow issues such as inadequate treatment capacity, scheduling conflicts (i.e., schedule for transporting waste to a facility does not coincide with that facility's operating schedule), and delays in the opening of a disposal facility. CWWFA is capable of quickly highlighting incomplete disposition alternatives that result in waste being orphaned. The tool provides rapid graphical feedback regarding the completeness and validity of an alternative.

Modeling Flexibility Encompassing Technical and Management Stakeholder Concerns

Environmental managers have expressed a need to be able to perform rapid, high-level trade studies and screenings of environmental management options. In addition to rapid analyses, CWWFA is adept at communicating information from engineering studies to managers and stakeholders for validation and increasing confidence in system plans and alternatives. This is accomplished by analyzing system parameters to find opportunities to disposition waste faster, save money, reduce risk, and graphically display relationships and results.

System Framework

To enhance CWWFA's ability to readily adapt to additional requirements, a flexible programming (object-oriented) development framework was chosen. This framework integrates waste flows, costs, and health and safety risks in one platform. The tool also provides an underlying framework that can be adapted to new applications such as environmental surety, defense programs, hazardous materials management, natural resource management, pollution prevention, and global policy models.

Graphical User Interface

The graphical user interface (GUI) was specifically designed to support communication of scenarios to non-technical audiences and as a high-level summary to an analyst. The GUI was designed in a hierarchical manner. The main screen of the CWWFA provides a high-level view of DOE complex and the relationships between sites. The user can point-and-click to "drill down" to site-specific information regarding waste/ material streams or facilities.

Top-Level Features

CWWFA has been developed to estimate and present tradeoffs between system alternatives.

CWWFA can:

• Track and project waste volumes and flows

• Identify dynamic schedule and resource allocation problems

• Highlight transportation study needs

• Estimate relative health and safety risks of proposed alternatives

• Provide decision support with analysis of stakeholder equity positions and variable sensitivity comparisons

• Manage large, complex data sets with configuration control and data validation

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The GUI of CWWFA displays summary information regarding waste type, quantity, and locations. The user can point-and-click to access detailed site-specific information such as facility operating data or individual waste stream characteristics. This figure depicts the location of all waste types present at 13 sites in the DOE complex at the beginning of the simulation.
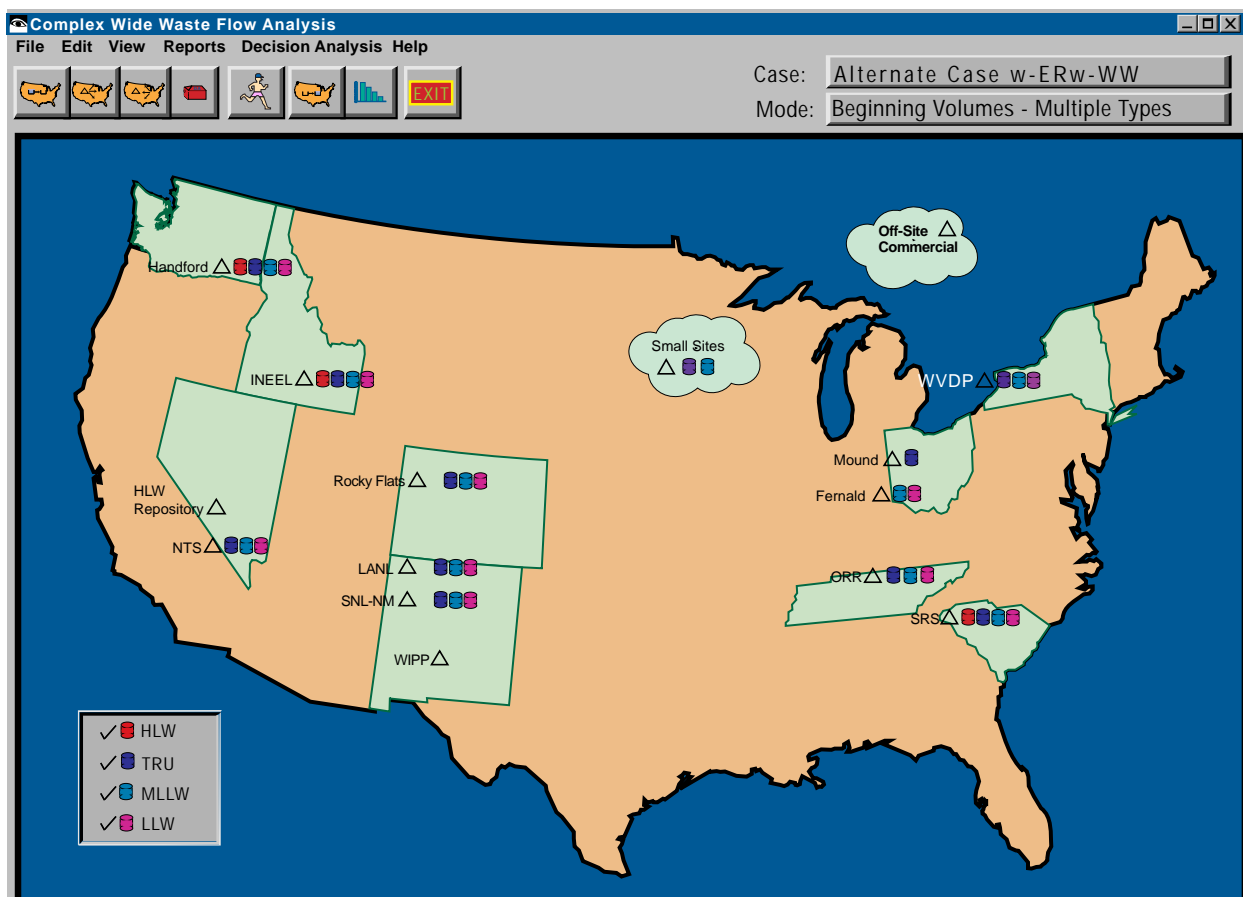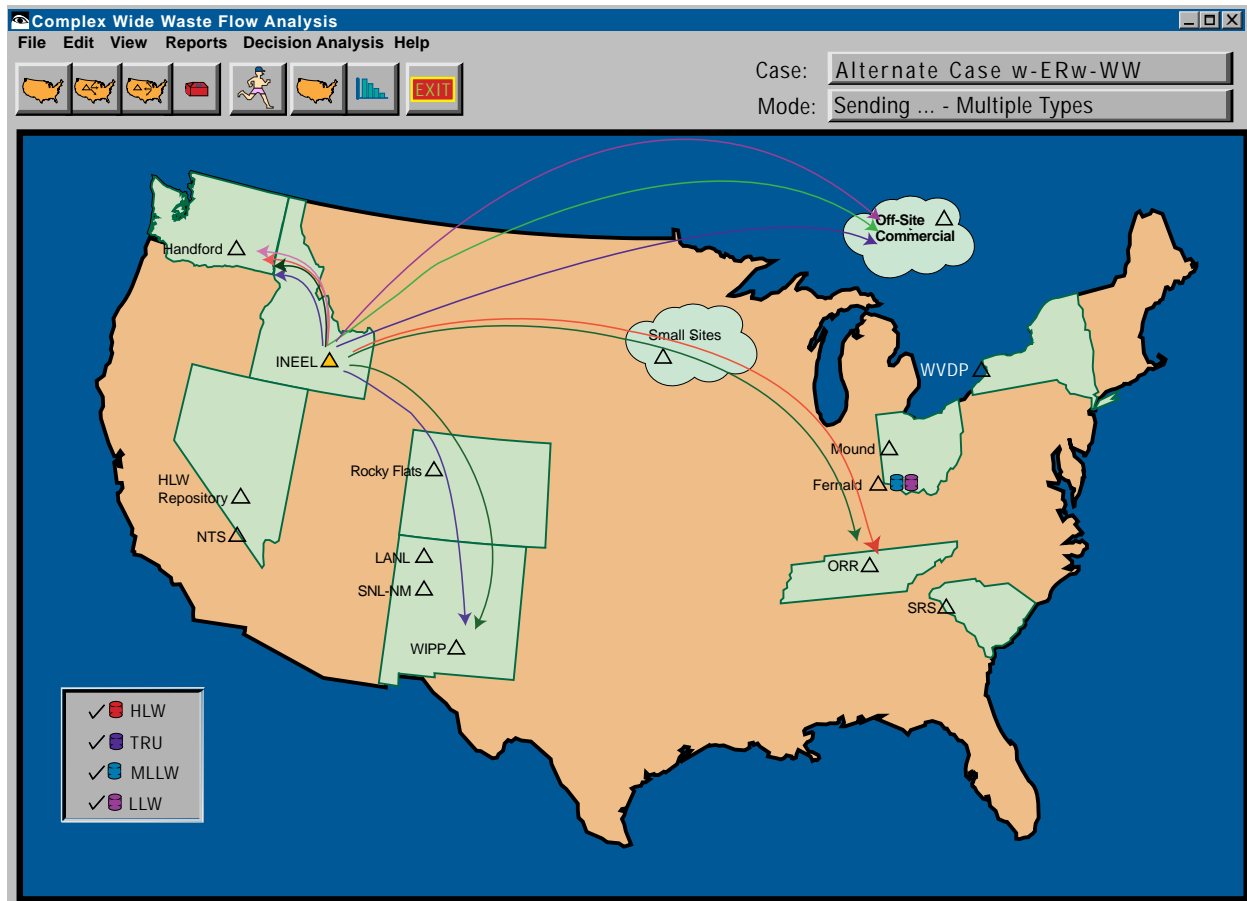
The GUI can also provide a summary of the interactions between sites that a given scenario represents. For this scenario, this figure indicates the type and destinations of waste that the Idaho National Engineering and Environmental Laboratory is planning to send offsite.

Life-Cycle Analysis

CWWFA provides for full life-cycle systems analysis, beginning with retrieval of inventory waste and continuing with any necessary pre-treatment, treatment, and post-treatment storage until final disposition (disposal, long-term storage, recycling). CWWFA also simulates all intersite transportation links. CWWFA provides the ability to vary factors defining engineering parameters of processing, transportation, and disposal.

CWWFA Scheduling

CWWFA provides quick interactive analysis of the effects of material (i.e., waste, product) flow over time. CWWFA summarizes impacts of acceleration, delay, and/or elimination of actions associated with various management activities (i.e., waste generation, pre-treatment storage, treatment work-off, post-treatment storage, shipping, and disposal). The tool has the ability to analyze multiple waste types (i.e., high-level, transuranic, mixed low-level, and low-level waste) concurrently.
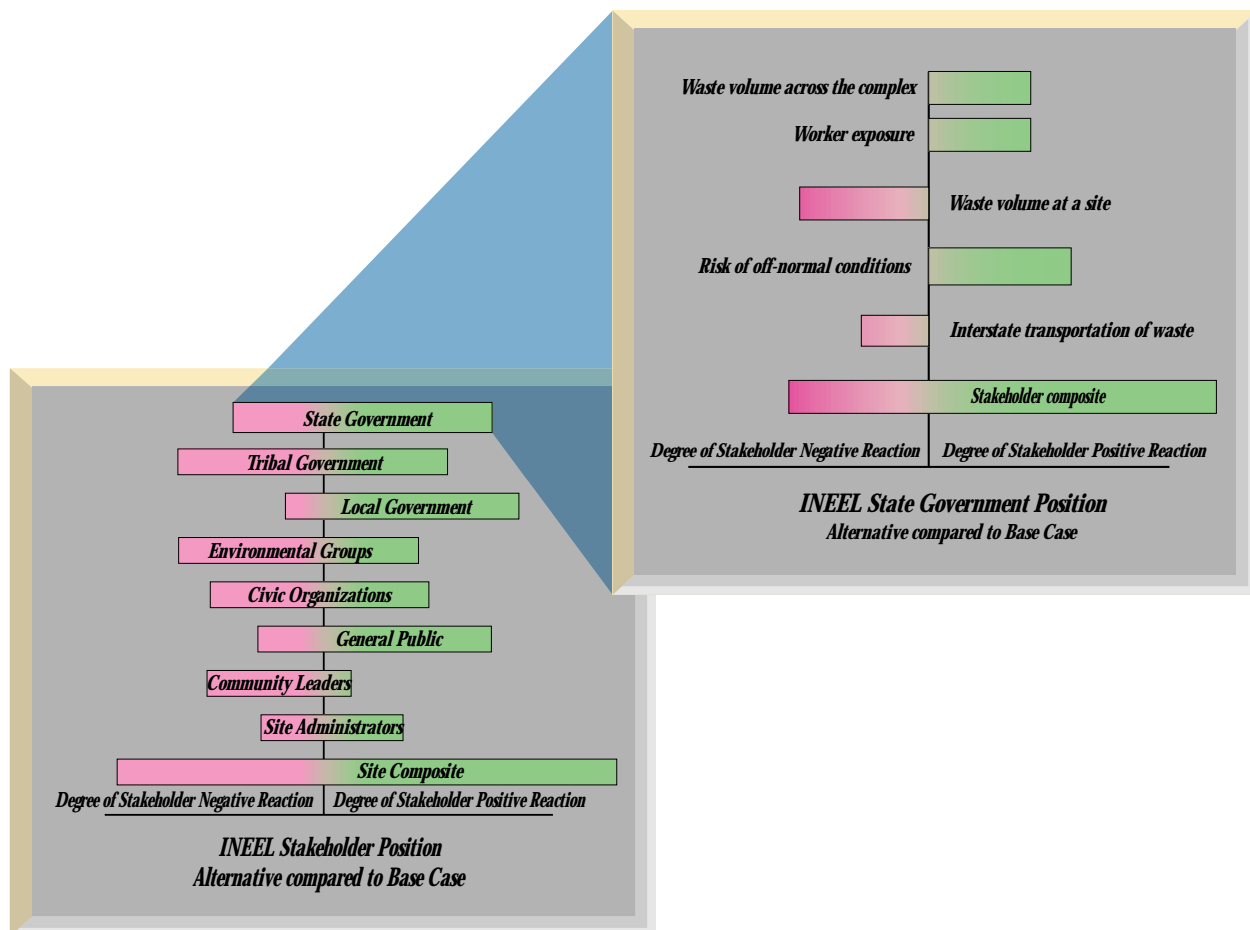
CWWFA has the capability to graphically represent both the positive and negative reactions of multiple stakeholders on several criteria of interest to them. The model provides the user the maximum flexibility to uniquely describe several stakeholders at each site and avoids a one-size-fits-all solution.

Transportation Studies

CWWFA simulates waste transportation by allowing the user to constrain the number of annual shipments of treated waste and then evaluating the impacts to storage and disposal. For example, the user can vary the treatment rate, number of shipment containers, transporters (e.g., trucks), and loading stations to see the impacts to receiving capabilities at a disposal facility.

Decision Support

CWWFA includes a decision analysis capability that provides meaningful insights into disposition choices, scheduling, political and regulatory constraints, and equity issues. The decision support functions fall into two areas: equity analysis and parametric sensitivity analysis.

Equity analysis provides relative estimates on how stakeholders may react (both positively and negatively) when evaluating two scenarios against a given set of decision criteria. As solutions are sought, the user gains insight into various stakeholder reactions across the complex.

The parametric sensitivity analysis allows the user to select from list of "objective functions." An objective function is a goal

(e.g., shorten cleanup schedule, minimize disposal volume) of interest to the user.

CWWFA performs parametric sensitivity analysis by running the model multiple times, varying pre-defined parameters through a range to determine which variable has the greatest influence on the objective function. This information is summarized in a "drivers diagram," displaying the variables in order of decreasing influence and their effect on the objective function.
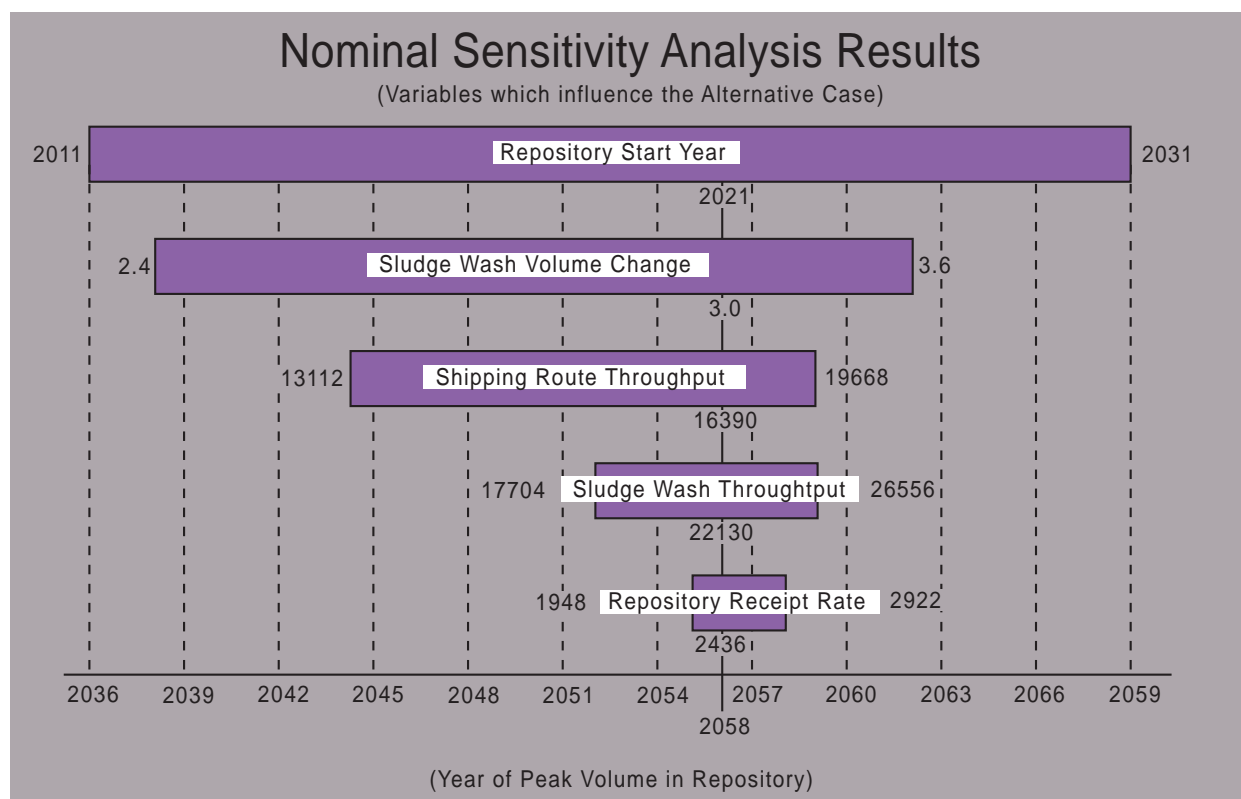
Health and Safety Risk Analysis

Risk analysis can be used to assess major discriminators of health and safety risks to workers and the public, rapidly screen waste treatment systems, and produce relative risk values consistent with more detailed health and safety risk assessments. The total relative risk calculation is a function of waste and site characteristics, and technology risk elements. The simplified risk method used in CWWFA is based on a fundamental equation of risk assessment (i.e., risk equals the probability that an event will occur multiplied by the consequences of the event).

Software Quality Assurance and Configuration Management Plan

For the product to be effective and useful, CWWFA users must have a high level of confidence in the data used and results generated by the software. The CWWFA Software Quality Assurance Plan and the

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This "drivers diagram" shows in decreasing order of influence, those variables that have the greatest impact on a given objective function. In this case, the objective function is "Year of Peak Volume in Repository," which is the year that 90% of the HLW in the complex has reached the repository for disposal. The variable of greatest influence on the objective function is the year that the repository opens for business, while the variable with the least influence is the rate at which the repository can receive waste per year.

Nominal Sensitivity Analysis Results
(Variables which influence the Alternative Case)

Variable	Low	Nominal	High
Repository Start Year	2011	2021	2031
Sludge Wash Volume Change	2.4	3.0	3.6
Shipping Route Throughput	13112	16390	19668
Sludge Wash Throughput	17704	22130	26556
Repository Receipt Rate	1948	2436	2922

X-axis (Year of Peak Volume in Repository): 2036, 2039, 2042, 2045, 2048, 2051, 2054, 2057, 2058, 2060, 2063, 2066, 2059

Waste Characteristics	DOE Site Characteristics	TSD Technology Characteristics
• Contaminant mobility • Radiological content (actinides, non-actinides) • Hazardous content (toxicity)	• Population data • Environmental challenges (e.g., seismic) • Environmental transport	• Confinement barriers • Waste form • Crew size • Worker proximity • Operational stresses (e.g., fires)

The health and safety risk estimated in the model uses site-specific waste characteristics and technology parameters.

Configuration Management Plan are part of the overall CWWFA project management effort to ensure that CWWFA is maintained as a quality product to meet Lockheed Martin Idaho's standards for software development, maintenance, and retirement.

CWWFA Features

System Dimensions

- HLW, TRU, MLLW, LLW disposition plans and waste interfaces
- Encompasses 13 DOE sites
- EM Integration baseline and alternative data sets

Input Parameters

- Volumes of current inventory waste
- Volumes of future generated waste
- Shipping routes and schedules between sites
- Facility-specific parameters such as volume change factor and operating time
- Transportation mode and packaging

Output Results

- Waste flows over time
- Facility utilization
- Number of transports to and from a facility
- Decision analysis capability
- Waste disposition
- Stakeholder equity

System Requirements

To efficiently use CWWFA to its fullest capacity the user should be linked to an INEEL server. The user's local computer system should include:

- Microsoft Windows 95 or Windows NT
- A monitor capable of running at 1024 x 768 resolution
- 32 megabytes of RAM.
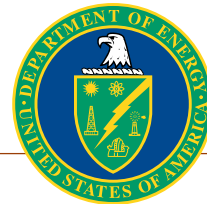
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